The Illinois Chemistry Teacher

A Journal of

THE ILLINOIS ASSOCIATION OF CHEMISTRY TEACHERS

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Supplementary Materials for High School Chemistry

Sycamore Community High School WALTER E. HANSWALD Sycamore, Illinois

In the few minutes allotted me I will give a brief review of the results of a survey carried on in this state relative to the use of supplementary reference materials in the teaching of high school chemistry.

The findings of this survey are based on the data gathered by means of a questionnaire submitted to more than two hundred of the Illinois high school chemistry teachers near the close of the 1934-35 school year.

The first problem encountered in drawing up the questionnaire was to determine which of the many popular chemistry references were to be included in this survey. To solve this problem all available published lists of recommended chemistry references were carefully examined and sixty-three titles were chosen on a basis of frequency of recommendation. The final questionnaire included a list of these references together with fifteen scientific periodicals, fourteen of the most widely used textbooks, and various questions regarding the use of reference materials in the teaching of chemistry. Some of the most interesting of the results obtained from the replies to the questionnaire will be presented in the remarks which follow.

Practically all of our schools reported some type of library facilities (99.1 per cent), and 83.0 percent of the cities in which these schools are located maintain a public library. As might be expected, a very small proportion of the smaller schools have access to the benefits of a public library.

The annual expenditure for chemistry reference materials ranged from nothing in a large number of schools to $275.00 in one of the schools of over 5000 enrollment. The median expenditure for all schools was only $12.00, which will scarcely provide two or three good books and a like number of periodicals each year. This situation becomes more striking when one realizes that half of the schools are operating on an even smaller expenditure. It is not surprising then, that the only supplementary chemistry references found in some schools are those books supplied gratis by the Chemical Foundation some years ago.

One of the questions asked all of the teachers was: What are the sources of revenue from which you obtain funds for purchasing reference materials? The replies to this question indicate that at least 90 percent of the schools obtained some of their funds from the general school appropriation, while only 10 per cent report the use of proceeds of student and club activities. It appears, therefore, that by various means the alert teacher could promote activities which would at least match the amount appropriated from the general school fund. In that way the $12.00 median expenditure mentioned a moment ago could be materially increased.

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LECTURE DEMONSTRATION VS. INDIVIDUAL LABORATORY WORK

In this issue of the Illinois Chemistry Teacher is presented a part of a symposium on a question much discussed at present, "The Class Room Demonstration vs. Individual Laboratory Method of Instruction in High School Chemistry". The papers here given in brief were selected from those given at the meeting of our Association in March of this year. Both sides of the question were presented. It is hoped that these papers will provoke some careful thinking concerning the question to the end that whatever method or combination of methods is used will be used more effectively. Too often we may allow work performed a number of times to become mechanical and give it little thought. The result cannot be the continued improvement that we desire. But by keeping in mind the points of superiority of the methods we use, we consciously, or even unconsciously, try to make our methods superior in these particular points.

There are two additional ways not usually mentioned in which laboratory work deserves credit. We cannot overestimate the value of getting better acquainted with the more bashful and timid students who need encouragement. Too often these students will not come to the teacher for the help they need. More often they are likely to become discouraged and become failures. In the laboratory the teacher can become better acquainted with the timid people, win them over, stimulate them, and cause them to get real satisfaction from chemistry.

Another value in laboratory work lies in giving the student a better appreciation of the chemist's work. By handling the tools of the chemist he gets an understanding and a feeling toward this work that can be obtained in no other way. Certainly, laboratory work is worth while if it causes the chemistry student to enjoy rather than hate the year's work in chemistry and if it causes students to appreciate more fully the work of the chemist.

CONFERENCE PROGRAM

The program of the morning and afternoon session of the chemistry teachers at the High School Conference at Urbana seems to be especially interesting this year. Both Mr. Leighly and Mr. Rahn are to be complimented for their work. Chemistry teachers will not forget the luncheon at noon which has been arranged by Mr. Glen Tilbury of Urbana High School. Our luncheons are always very informal and for that reason enjoyable. You get acquainted with the people you like to know under circumstances that eliminate stiff formalities. Every one should plan to come. Reservations can probably be made up to 10:30 A. M. Friday of the Conference.

The place and time for the Spring Meeting of our Association will likely be considered. If you want the Association to meet in your section of the state now is the time to extend an invitation and start planning for it.

Values of Laboratory Work

Moline High School CARL E. EKBLAD Moline, Illinois

One of the trends in our contemporary education has been to emphasize the importance of pupil activities in the learning process. What the teacher says or does may not be as important as what the pupil himself does in bringing about the learning adaptation. This pupil activity may manifest itself in a number of ways; the study of the textbook material, the working of problems and exercises, participation in individual or class projects of various kinds, and the responses to his instructor's questions in the classroom are merely a few of the many activities accorded to the pupil in his school life. The high school course in chemistry with its laboratory and laboratory materials, offers the pupil large opportunities to engage in such useful activities as the objectives of the course may prescribe. Of these objectives there are those which contribute to the gaining of factual knowledge; those which contribute to the attainment of skills and habits, and those which are involved in the exercising of various mental processes such as observation, induction, deduction, and generalization. The object of this paper will be to discuss the relative values of these activities and the type of experiments which may be used to produce them.

One of the common criticisms of laboratory work is that in spite of the work and expense involved, the attainment of factual knowledge gained by the performance of experiments in the laboratory is no greater than that attained through a study of the textbook or through observation of experiments performed and explained by the instructor. If such criticisms are based upon the results of valid tests, there may be some justification for them. But the mere attainment of factual knowledge is not as important as the method by which the knowledge was attained. The high school pupil is no reservoir into which knowledge can be poured. He is a living individual who learns best through experience, that is through self-activity. The pupil who has set up a distillation apparatus for the first time and separated a volatile substance from a non-volatile one has gained whatever knowledge the experiment offers through his own activity and through his own effort. Whether the quantity of learning so obtained is any greater than that obtained by a demonstration of the experiment, only the results of educational research could show, but it is quite certain that the self-satisfaction and the thrill of achievement is much greater. Hence experiments which lead the pupil to some practical result or some product which he can describe, display and keep or even use will encourage that desire "to do" and at the same time afford him an opportunity to acquire factual knowledge through experience. For the pupil the high school laboratory is a storehouse of chemical facts, the assimilation of which is only commensurate with his ability.

Most teachers will agree that the development of skill and proper habits in the manipulation and setting up of chemical apparatus is one of the desirable objectives of a course in high school chemistry. Yet at the end of a year some of the pupils show an appreciable lack of skill and many of the good habits acquired in the beginning of the course have apparently been lost. Perhaps one of the reasons for this situation is the fact that many of the procedures that tend to develop skill in the use of apparatus are performed only once and never repeated. Writers of laboratory manuals are so anxious to present as much material as possible in the field of elementary chemistry that there is neither room nor time to repeat many of the procedures intended to teach laboratory technique. Hence experiments which tend to repeat procedures previously practiced and adapt them to new learning situations seem to be the ones which

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Lecture Demonstration vs. Individual Laboratory Work

Monmouth High School JOSEPH D. DIXON Monmouth, Illinois

A variety of problems and conditions govern our choice of the proper chemistry course we offer our students.

We probably all agree that the demonstration method allows for the performance of experiments in much less time, and at a lower cost than the individual laboratory work. The reasons for that are quite obvious, I think. This reduction allows the student contact with a larger number of experiments during the year. It allows for the purchase of more expensive equipment, since just one unit need be purchased. More interesting experiments can thus be performed.

The average pupil is limited in his capacity to perform experiments. In the first place he is limited in his ability to interpret the written directions from the oridnary prepared lab manual Following that many of the manipulations are not carried out correctly. Too much of this or that is added, connections of apparatus are not properly made, materials are heated too much or too rapidly, etc. All of this leads to wrong results and consequently wrong conclusions. One of my students in studying water softening was told to pass carbon dioxide through lime water until a precipitate formed and to continue until a subsequent change occurred, then heat the solution. Not realizing the meaning of "subsequent change" he formed the precipitate in lime water, continued the carbon dioxide for a short time and heated the suspension. Naturally, no appreciable change took place, and he reported it as such. Such mistakes would not occur in lecture demonstration work and wrong results and conclusions would be avoided. Attention of the class can be drawn to these points during the experiment. The pupils attention is focused on the correct procedure, manipulation and result. In individual laboratory work the pupil often gets discouraged by his own improper apparatus and results. Very often the too-simple and obvious experiment also leads to a lack of interest on the part of the pupil.

The two methods compared on the basis of tests given upon completion of courses using the two methods, shows a variation in results although they favor the demonstration method. Payne in the Chemical Journal for July, 1932, tells of such an experiment with classes in beginning college chemistry. He arranged, on the basis of pre-tests, six groups of two paired sections each. These included 299 students from four colleges taught by five different instructors. One section out of each group received instruction by he lecture demonstration method for one semester, while the paired section was taught by the individual laboratory method. At the end of the first semester they were all put into the individual laboratory classes and taught by that method the second semester. He found that his study did not produce any uniformly significant results. In one group the laboratory section outranked the demonstration section. In another group the demonstration section led the lab section at the same period in the test. There was but a slight difference in their scores in most all cases. His results did seem to show that the poor students profited more by the demonstration method than by the lab method.

Elder in the Journal of Chemical Education for Feb. 1936 reports in the questionnaire in which he asked the following question: "Do you believe in the demonstration method?" 16 per cent answered yes, while 84 per cent answered no. Some of the reasons accompanying these were: (1) No: each chemical problem is an individual case and must be treated as such. The student realizes this only when in actual contact with the experiment. (2) No: every student should have some training in the technic of some experimental science and in the scientific method. (3) No: does not train a student to do a thing for himself, observe and draw conclusions from his own observations. (4) No: I believe that students learn more by actually doing a thing than by seeing it done no

matter how far superior to their efforts the demonstration may be. (5) Yes: A very small percentage of students follow up chemistry; those who do not lose the laboratory knack and knowledge gained in laboratory very quickly. (6) Yes: Expensive lab work for the mass of credit hunters is a waste of good public funds. Of course, we would not give the demonstration lecture courses alone to the real chemistry and medical students.

These opinions, while not proving anything, bring out some of the salient objections to both methods. I agree with those who believe that a student learns more by actually doing the thing himself. Various details are noticed by the student at close range that can not be shown to him, or conveyed to him in words. At the same time, students have a certain pride in accomplishment. They should learn that that accomplishment can be realized by their own efforts through proper manipulation, observation and conclusions. While we do not want to teach from faulty experiments, a student can learn valuable lessons from incorrect results if properly analyzed. In watching experiments performed correctly all the time, the student gets the idea that the materials have to be merely thrown together to reach the desired goal. In performing his own experiment, he finds it isn't as simple as that. I like to have my students meet those conditions in their individual problems they encounter in laboratory work, so that even though they do not follow up chemistry, and do not meet these problems again, they realize the work of the scientific worker isn't just a job of hitching up the apparatus and dumping in the chemicals. A certain appreciation and reverence for scientific work is developed in the student through his own manipulation of the experiment, even though that manipulation is far from skillful.

Manipulative skills are probably not retained by those not going on with chemistry, but aren't they needed by those who do? Most colleges are grouping their beginning chemistry classes into groups that have had high school chemistry, and those who have not and are assuming that the former have these manipulative skills and are ready to go on with more advanced work. We need to prepare these students so that they can carry on successfully. Our own State University is even giving credit for beginning chemistry without the student taking the course, providing he can pass the test on the facts and skills required to allow him to do advanced work.

In conclusion and summary, let me say that:

1. I believe there is a place for both types of experimental work, the more difficult and costlier experiments by demonstration, and the simpler yet not too obvious experiment by individual lab work.
2. The type of student and teacher governs, to a large degree, the method used.
3. There is a need for more definite objectives for teaching chemistry.
4. More definite objectives for each experiment are needed regardless of the method used.
5. The demonstration method is best suited to those not going on with chemistry.
6. The literature I have read does not prove conclusively that either method is superior for all types of students.
7. The demonstration method is faster and cheaper and allows for a greater variety of experiments.
8. The demonstration method is more orderly in that lecture work and laboratory work are more easily correlated.
9. The laboratory method better allows for individual achievement.
10. Laboratory work better allows for the development of individual skills.
11. Laboratory work instills a greater reverence for scientific work.
12. The trend in modern education toward regementation of students has led us to search for a method whereby we can more easily teach the masses, rather than allow for individual differences in students. Perhaps in the end, the long way around may be the most beneficial to the student.

SUPPLEMENTARY MATERIALS

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Another portion of this study revealed that half of the schools have less than ten chemistry references available for student use. The school libraries, nevertheless, are better equipped to meet the demand for interesting collateral reading than are the public libraries with a median of less than six references. The situation seems a little improved in the case of scientific periodicals since, without regard to size, the majority of the schools subscribe to two or three science magazines. This offering is somewhat increased by the personal subscription of the instructors and assistance from city libraries. A fairly adequate supply of supplementary textbooks is indicated by the fact that more than half the schools have at least five such references. So much for the availability of chemistry reference materials. Let us now look to the degree to which these materials are actually used in the teaching of chemistry.

An analysis of the replies shows that 70.0 percent of the teachers having a masters degree or higher make use of popular reference books regularly or often, while only 55.4 percent of the teachers having a bachelor's degree or less make use of such teaching helps to this extent. This difference is more pronounced in the use of periodicals by a margin of 64.6 percent to 41.5 percent. This increase in both the use of books and periodicals in the classes taught by those teachers having additional training may be partially explained by the fact that such teachers are more often employed in the large high schools which have a greater supply of reference materials at hand. However, I believe this also indicates that those progressive teachers who are keeping abreast of the times are aware of the value of additional reading in the teaching of chemistry.

To gain some idea of the purposes served by the use of supplementary references the teachers were asked to check from a list of seven possible outcomes those which they had in mind when assigning or encouraging the use of additional reading materials. The majority of the teachers seem to agree that such reading will contribute to: first, an increased interest in chemistry, second, to pointing out the more practical applications of chemistry, and third, to a solution of the problem of individual differences.

As a further check on the use of references, the teachers were asked to indicate whether oral reports were made by the students upon the references used. The ratio in favor of the use of these reports was about three to one (75.7 percent to 24.3 percent).

Let us now turn to the titles of reference materials most frequently found available and used to supplement the chemistry texts.

Of the nine or ten books found in the typical high school chemistry library the following titles are most likely to be available. The numbers with each title indicate the percent of schools reporting each book.

1. 87.3 Slosson "Creative Chemistry".
2. 54.0 Caldwell & Slosson, "Science Remaking the World".
3. 54.0 Vallery-Radot "Life of Pasteur".
4. 52.0 Lefebure "Riddle of the Rhine".
5. 51.2 Howe "Chemistry in Industry"
6. 50.5 DeKruif "Microbe Hunters".
7. 44.5 Chamberlain "Chemistry in Agriculture".
8. 40.3 Gregory "Discovery—The Spirit and Service of Science".
9. 38.7 Chemical Foundation "Future Independence and Progress of American Medicine---"
10. 34.5 Hodgman & Lange "Handbook of Physics and Chemistry".

Of these books the instructors more often assign reading in Howe's "Chemistry in Industry", Chamberlain's "Chemistry in Agriculture", and Slosson's "Creative Chemistry".

The six scientific periodicals most frequently found in the high school libraries are: (1) Popular Science Monthly, (2) Popular Mechanics, (3) Science

Leaflet (formerly the Chemistry Leaflet), (4) Nature, (5) Journal of Chemical Education, (6) Scientific American. While the "popular" type of science magazines are more frequently found in the high schools the teachers report the greatest use of the Science Leaflet (Chemistry Leaflet) and the Journal of Chemical Education as assigneed references.

One rich source of authentic and interesting information is the mimeographed and printed literature distributed by industrial concerns. These materials, usually free from objectionable advertising, are quite valuable in describing and illustrating various phases of the many applications of chemistry to useful everyday practices, materials, processes or commodities. A list of thirty-three topics upon which such literature is available was included in the questionnaire and the teachers checked those topics only in case they had such materials for the use of their students. The median number of topics for all schools was less than eight, with petroleum products, baking powders, and fuel gas most often available.

So much for the present situation. What improvements can be made? What can we do to make our library offerings more complete and worthwhile? In answer to these questions I offer the following suggestions with the hope that our supply of chemistry reference materials may be increased. **First:** Know what books are available and best adapted to your needs. Don't be caught napping when the opportunity comes for obtaining additional books for your chemistry library. Your administrative officers will be much more likely to supply the needed money if you are certain of the materials you desire to be purchased. The following book lists will give valuable help in choosing books most suitable for your needs.

1. Culp, V. S., Noyes, W. A., and Reed, Rufus D. "Report of the Committee on Chemistry Libraries". Journal of Chemical Education, Vol. 11, 2, 1934, p. 114-123.
2. Hunter, George W. "Science Teaching at Junior and Senior High School Levels", Chapter 14, p. 445-485. American Book Company, Chicago, 1934.
3. Webb, Hanor A. "The High School Science Library", Peabody Journal of Education. Vol. 3, p. 85-119, 340-347, 1926; Vol. 4, p. 351-358, May 1927; Vol. 5, p. 278-290, March 1928; Vol. 7, p. 1-16, July 1929; Vol. 8, p. 35-48, July 1930; Vol. 9, p. 29-40, July 1931; Vol. 10, p. 20-31, July 1932; Vol. 11, p. 1-10, July 1933; Vol. 12, p. 57-88, Sept. 1934.
4. Franks, J. C. "The Teaching of High School Chemistry" 5th ed. Chapter 14, p. 190-196. J. O. Franks & Sons, Oskosh, Wis. 1932.
5. Gere, Miss Muriel C., Gunther, J. J., Hendrick, B. Clifford, "The High School Chemistry Library, Some Desirable Offerings", School Science and Mathematics, Vol. 29, p. 859-863, 1929.
6. Schmidt, Meta, "Five Hundred Books for the High School Library", American Library Association, Chicago,
7. "Books and Magazines Recognized for High Schools", John C. Hanna Circular 239, State Dept. of Public Inst. Springfield, Ill. 1929.
8. Pruitt, C. M. "Science Reading Materials for Teachers and Pupils", Science Education, Vol. 16, p. 38-46, 116-124, 201-208, (1931-32).
9. "Lists of Books for a High School Student's Reading" 2nd. Td. Lakewood High School, Lakewood, Ohio 1930.
10. "Library List for High School Teachers of Science and Mathematics", Maryland School Bulletin. Vol 10, No. 5 (1928). State Dept. of Educ. Baltimore, Maryland.
11. Lathrop, Edith A. "Aids in Book Selection for Secondary School Libraries". Pamphlet No. 57 U. S. Dept. of Interior Superintendent of Documents, Wash. D. C. (5 cents) (lists other library lists that are good).

Second; Cooperate with your local city library board. Make up lists of books recommended for purchase. I am sure you will find most librarians willing to do whatever is possible to meet your needs.

Third; Make use of the vast store of

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PHYSICAL SCIENCE PROGRAM

HIGH SCHOOL CONFERENCE

University of Illinois, Urbana, Illinois

FRIDAY, NOVEMBER 6, 1936

MORNING SESSION

Chairman: H. P. Leighly, Rantoul Township High School

9:00 Occurrence, Manufacture and Uses of Some of the Rarer Metals—Dr. Clarence W. Balke, Research Director, The Fansteel Metallurgical Corporation, North Chicago, Illinois.

9:50 Electrostatics (one reel moving pictures). Metals of a Motor Car (two reels). Both films from the Visual Aids Service, Extension Department, University of Illinois.

10:20 Improving the Physics and Chemistry Courses in Illinois High Schools. Fifteen minute discussions by the following: Professor R. F. Paton, Physics Department, University of Illinois. Professor J. C. Bailar Jr., Chemistry Department, University of Illinois. Mr. W. E. Harnish, University High School, Urbana, Illinois. Mr. Allen R. Moore, Head of Science Department, Morton High School and Junior College, Cicero, Illinois. Mr. Charles C. Stadtman, Assistant Superintendent of Public Instruction, Springfield, Illinois.

12:15 Chemistry Luncheon, University Place Christian Church, Wright and Stoughton Streets, Urbana. (Go west from Physics Building to stop sign, then north on Wright Street two blocks).

AFTERNOON SESSION

Meeting of Illinois Association of Chemistry Teachers

Chairman: Herman R. Rahn, Mattoon High School

2:00 Some Observations During Thirty Years of Chemistry Teaching—George C. Ashman, Bradley Institute, Peoria.

2:20 Adapting the Summer Session of the University of Illinois to the Chemistry Teacher—B. S. Hopkins, Professor of Chemistry, University of Illinois.

2:50 The Place of Organic Chemistry in the High School—Nicholas D. Cheronis, Department of Chemistry, Wright Junior College, Chicago.

3:20 First Aid in the High School—Joseph H. Beard, University Health Officer, University of Illinois, Urbana.

3:40 Scientific and Economic Considerations Involved in Chemical Warfare (Illustrated)—Ray C. Soliday, Department of Chemistry, Oak Park and River Forest Township High School.

(Note: Reservations for the chemistry luncheon may be made by mailing a card at once to Mr. Glen Tilbury, Urbana High School, Urbana, Illinois. Cost is 45c per plate.)

WANTED: ONE HUNDRED PERCENT

The Slogan of our State Chemistry Association is "Every Chemistry Teacher an Active Member". Every teacher will want to help the Association move forward for the advancement of his profession. He will want a membership card, which may be obtained by sending fifty cents for one year, or one dollar for two years, to Mr. S. A. Chester, Secretary of the Illinois Association of Chemistry Teachers, Bloomington High School, Bloomington, Illinois. He will want to come to the programs and have a part in its work. Our goal is one hundred percent membership and one hundred percent service.

Class Demonstration vs. Laboratory Work

Peoria Central High School J. H. SAMMIS Peoria, Illinois

Within the last two years there came into my possession some thirty-six magazines which I valued enough to want them bound. I inquired about the price of binding them at a local book bindery, and found the price higher than I thought (at the time) justifiable. It seemed to me that I could possibly bind the magazines myself. I had had no previous experience.

Presented to me as I considered the situation were two alternatives. I could adopt the laboratory method in the form suggested by the most ardent of the "do it all yourself with your own hand and your own method" advocates or I could study the matter in the light of what others had found out by reading and watching someone else do some actual bookbinding, more in the manner of the proponents of the lecture demonstration methods. I chose the latter method, just as I believe would have most persons confronted with the same problem.

When we offer as a reason for the superiority of the laboratory method over the demonstration method the fact that the student learns best by actually finding things out for himself experimentally are we not overlooking the fact that though the above statement may be true it has little to do with our problem? Are we not overlooking the fact that as high school chemistry experiments are customarily performed they are not really experiments at all in the true sense of the word? We know if we are honest with ourselves that the performance of such experiments is largely the following of directions that invariably lead the pupil inescapeably into the answer, assuming some small degree of thinking on the part of the pupil. He is not experimenting; he is following.

If what I have said so far be true then laboratory work does give some training in following directions, and I for one would be the last to complain if I could see evidence that that was actually being accomplished—I like to think it is. As for stimulating original thinking, I believe we are doing very little of it in the high school laboratory; the university student doing research work in the laboratory, yes, but not the high school pupil reading his cook book. If we really took ourselves seriously about getting the high school pupil to doing original experiments we had better build our laboratories in remote regions, well separated from the main buildings, like the mixed buildings at a powder plant.

In our daily experiences which are we called on oftener to do?—perform an original experiment or learn an operation or result from someone else who has already made all the necessary or likely mistakes? Shall we find out first hand that sulfur and potassium chlorate ground together will blow off a hand or will we be content to take the word of authorities who have found out before us?

It has always seemed to me that whenever the present controversial subject is discussed we teachers are inclined to prove or disprove our contentions in the light of the ideal rather than the actual situation. I can conceive of a class of perhaps five to ten above the average young people intensely interested in chemistry who might make it possible to conduct the laboratory portion of the course in such a manner that some original thinking might be forthcoming, but most of us are not fortunate enough to have such classes. On the contrary, we are more likely to have about thirty assorted pupils, a goodly portion of whom are taking chemistry because they are required to take some science and chemistry was rumored to be easier than physics and not so messy as biology. Expecting more than a mediocre sample of direction following from such pupils seems to be optimism of the highest sort.

When we remove our rose-colored glasses and look at laboratory work as it really is and not as what we would like to have it there appears to be much

to commend the demonstration method of conducting "experiments". Some of the well-known advantages which cannot be contested (though their importance may be) are: cheapness due to more economical performances by instructors, fewer repetitions due to fewer failures in results, and fewer performers; greater safety; increased number of experiments that can be performed in limited time; less confusion due to errors. On the other side of the ledger is the oft-mentioned fact that actual manipulation of equipment gives the pupil training in using his hands, in greater dexterity.

What about this acquisition of manual dexterity? Is it really acquired or are we again doing a little wishfull thinking? Such skills are difficult to measure and so we have little statistical help in answering this question. In the course of a one year high school chemistry course few schools actually can give more than 120 clock hours of laboratory work. Of that time at least half of it is not occupied with the handling of equipment, leaving some 60 hours. And now just what is it that constitutes this "handling"? Is it something unique only to laboratory sciences or is it about on the same level as table waiting? Lighting the gas stove, wiping dishes, using the measuring cup, pouring water from the decanter into the tumbler, straining the fruit juices, and weighing the sugar for the preserves strike me as being startlingly analogous to those sacred rites of the laboratory that are so often offered as reasons for allowing the pupil to "do it himself". I do not mean to belittle those necessary techniques. On the contrary, I believe them to be most important but, though I dislike thinking it, I cannot see around the fact that they could as well or perhaps better be taught in courses in handicrafts, in the kitchen, or in the shops.

As for results on the basis of useful information acquired and held by each of the two methods, what evidence we have is rather contradictory and confusing. If a series of education experiments

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SUPPLEMENTARY MATERIALS

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free materials available by writing to various industrial concerns.

(Copies of this list may be obtained by writing the author).

Fourth; Make greater use of the opportunities you have for putting on activities to raise money for library books and magazines.

Fifth; Watch for announcements of cheaper editions of good books. Get in touch with the second-hand book dealers. Many have bargains in slightly used or shop-worn copies.

Sixth; Be sure to keep up with your subject by subscribing to at least one or two good scientific periodicals.

You have probably expected me to present an argument in favor of the use of reference materials. I do not feel such an argument is necessary. When we realize that less than one in ten of our high school chemistry students will continue with chemistry in college, and that a much smaller percentage will make chemistry a life work, it then seems unwise to make college preparation the chief aim of our high school chemistry course. We must shift the emphasis to a greater appreciation on the part of the students for the values of chemistry.

Various educational studies have shown that much of the factual material taught in our high school chemistry courses is not adapted to the needs of the students and is not being mastered to a satisfactory degree. Other studies show that little of this factual ma'erial is retained after a period of a few months. Such evidences place the propaeductic function of high school chemistry in bad repute and further emphasize the need for a shift in emphasis.

That the public is grossly ignorant of chemistry and its effects on our lives needs no argument. This ignorance exists even among people who are supposedly educated and in charge of affairs of state and society. It is important, therefore, that this ignorance be dispelled and that the leaders of the future have some insight into the workings of chemistry, not as specialists in the field, but as cultured citizens.

In conclusion I suggest that we aim for a greater appreciation of the part chemistry plays in our everyday life. This appreciation to be brought about by abundant reading of recreational materials.

CLASS DEMONSTRATION

(Continued from page eleven)

show the demonstration method to be superior the advocates of the laboratory method point out that many of the useful things acquired by the latter method are not measureable, and that objective tests showing the superiority of the former method are inadequate in that they do not take acquired manual skills into account. The fact that they fail in this does not necessarily prove that those skills were ever acquired. The overage adult succeeds fairly well in fastening a hose to a faucet without the preliminary training of setting up chemical ware involving rubber tubing.

We would be seriously opposed to any measures aimed at removing laboratory work from the university courses in science where the pupils concerned were endeavoring to obtain training so that they might later follow scientific pursuits, if such a thing were ever proposed, but in the secondary level we cannot help but feel that many of the experiments commonly found in our high school chemistry courses could well be done as lecture demonstrations, particularly where the pupils are required to take accurate notes and turn in significant write-ups. It is our opinion (and admittedly only opinion) that the demonstration method, while not superior to the laboratory method in many respects, is at least its equal and that in view of the obvious savings could well supplant perhaps a part of the laboratory work.

VALUE OF LABORATORY WORK

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will train the pupil to use properly the tools of the chemist.

An important learning principle involved in laboratory work is the so-called principle of initial diffuse movements. Observe the many useless and random movements made by the pupil in the process of doing his laboratory work. As time goes on, however, he soon learns to eliminate those of no value to him and select and use only those which will aid him directly in the performance of the experiment. Witness, for example, the pupil lighting his Bunsen burner for the first time. After carefully adjusting the collar, he holds the box of matches in one hand and the lighted match in the other. He then finds that he needs another hand with which to turn on the gas. Before he can lay the box of matches down the lighted match is already beginning to burn his fingers and so he drops the lighted match and begins again. These little failures and successes are needed to train the pupil to coordinate mind and muscle and the laboratory can be to him a proving ground where he may learn to focus his time and energy to the accomplishment of some useful task. Then too, where pupils work together in groups, habits of cooperation and teamwork may be fostered. The pupil who has the opportunity to do something that may cause injury to others and then learns to control and restrain the impulse has certainly taken a large step in the process of becoming a good citizen. Experiments which require group work may also be of value in the course.

Early in his chemistry course, the pupil is told to observe carefully the facts and results of his experiments and to make his generalizations from such facts. But many pupils soon fall into the habit of consulting the textbook for facts and principles which should have been obtained directly from the experiment and thus defeat one of the objectives of the course. The pupil, however, is not entirely at fault. The nature of experi-

ment and the questions asked are usually the cause of this situation. Many of the questions asked are not in regard to what the pupil observes but rather in regard to what we want him to observe. And since credit is usually given for the latter and not for the former, the chief concern of the pupil is to find an answer to the question and not to spend time in a study of the experiment. Hence if experiments can be given the pupil which will lead him to ask himself questions, then he will be more likely to make direct use of the facts shown in the experiment rather than to consult the textbook. Such experiments should involve activities which will encourage the pupil to find out the facts through observation and to develop the questioning attitude of mind.

In every high school chemistry class there is at least one pupil of exceptional ability for whom the laboratory is an opporunity to develop his talents. In the classroom he is required to participate in the discussion of textbook material which offers him little that is new to him or which is so comprehensible to him that it does not challenge him to think. But in the laboratory he has an opportunity to work at his own level. Such a pupil can be given projects and advanced laboratory work which will encourage and develop his latent abilities.

It is believed, therefore, that the laboratory work provides useful activities which contribute to the attainment of the many objectives of a high school chemistry course. Since the needs of the pupils constantly change, the experiments of the laboratory course should be changed so as to meet these needs. In this way the laboratory work will become enjoyable and more profitable to the high school student of chemistry.

The Illinois Junior Academy of Science has shown a steady growth each year in paid up membership indicating a growing interest among science teachers toward the development of project work. If interested write Louis A. Astell, University H. S., Urbana, Ill.